LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

UCRL-CONF-203213

Surface-Layer Turbulence During a Frontal Passage

M. Piper, J. K. Lundquist

March 28, 2004

16th Symposium on Boundary Layers and Turbulence
Portland, ME, United States
August 9, 2004 through August 13, 2004

Disclaimer

Surface-layer Turbulence during a Frontal Passage

Mark D. Piper and Julie K. Lundquist

Very little is known about the nature of turbulence in the transition zone of a synoptic-scale cold front, especially at the dissipative scales. Lacking this knowledge, accurate models of surface frontogenesis are compromised. To address this problem, high-frequency measurements from sonic and hotwire anemometers are used to analyze the fine-scale turbulence in the atmospheric surface layer (ASL) within a cold front observed in the MICROFRONTS field experiment. To quantify the turbulence in the front, velocity spectra and dissipation rates are calculated as functions of time and stability in the ASL.

The normalized first and second moments of the one-dimensional velocity spectrum conform to the scaling suggested by Kolmogorov's equilibrium hypotheses, even during the intense turbulence associated with the frontal passage. The spectra compare well with other data collected at high turbulence Reynolds number in the ASL, but not as well with a recent model of the dissipative range of turbulence.

Dissipation rate is calculated with one direct and two indirect techniques. The calculations from the different techniques compare well with one another and, when nondimensionalized, with a historical expression for dissipation rate as a function of ASL stability. The magnitude of the dissipation rate increases by an order of magnitude to a maximum value of 1.2 m2 s-3 during the frontal passage compared to prefrontal values of 0.05 m2s-3; the latter is typical for a slightly stable nighttime boundary layer over land.

These results can be used in assessing the effects of turbulence in traditional semigeostrophic models of frontal collapse. The dissipation rate calculations may be of particular use to modelers.

Support for MP has been provided by the Air Force Office of Scientific Research under grant F49620-95-1-014-1 and under AASERT grant F49620-97-1-0448. Support from the Atmospheric Sciences Division, Mesoscale Dynamics Program of the National Science Foundation, under grant ATM-9903645, is also acknowledged. The LLNL component of this work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.